AGRICULTURE

# Sustainable Intensification in Agriculture: Premises and Policies

Clearer understanding is needed of the premises underlying SI and how it relates to food-system priorities.

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Food security is high on the global policy agenda. Demand for food is increasing as populations grow and gain wealth to purchase more varied and resource-intensive diets. There is increased competition for land, water, energy, and other inputs into food production. Climate change poses challenges to agriculture, particularly in developing countries (*1*), and many current farming practices damage the environment and are a major source of greenhouse gases (GHG). In an increasingly globalized world, food insecurity in one region can have widespread political and economic ramifications (*2*).

These challenges require action throughout the food system. One response has been a call to increase food production from existing farmland in ways that place far less pressure on the environment and that do not undermine our capacity to continue producing food in the future. This "sustainable intensification" (SI) approach is a policy goal for a number of national and international institutions (*3*–*5*) but also attracts criticism as being too narrowly focused on production or representing a contradiction in terms (*6*).

The origins of SI lie in discussions about increasing yields, chiefly of arable crops, in the face of resource scarcity and environmental challenges (see the photo). Our goal here is to articulate a more sophisticated definition of SI, one that clarifies the logic on which it rests and the context and conditions within which it should be implemented. We define four underpinning premises of SI, situating it within a broader framework of priority actions for the food system. We then explore how SI interfaces with other major food-system goals and show how they may guide SI implementation. We argue that this broad perspective is essential if SI is to fulfill its goal of helping foster global food security.

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### Four Premises Underlying SI

(i) The need to increase production. The challenge of achieving sustainable food security for all is only in part a supply-side problem (*2*, *7*, *8*). Urgent action is also needed on moderating demand for resource-intensive foods (such as meat and dairy products), reducing food waste, and developing systems of governance that improve the efficiency and resilience of the food system, as well as making food accessible and affordable to all.

Nevertheless, overall increases in production are essential because no one approach to address food insecurity will be fully effective, given the inevitability of policy failures, as well as the time lags in the demand and supply dynamics of the food system. It is too risky to assume otherwise. Yield increases in many low-income countries are required today; elsewhere, the goal may not necessarily be to increase yields immediately but to develop the potential to respond to future increases in demand. Critically, all responses must be environmentally sustainable. SI should be seen as part of a multipronged strategy to achieving sustainable food security rather than an all-encompassing solution.

(ii) Increased production must be met through higher yields because increasing the area of land in agriculture carries major environmental costs. Although land usable for agriculture exists, it consists mainly of forests, wetlands, or grasslands, whose conversion would greatly increase GHG emissions (*9*) and the loss of biodiversity and important ecosystem services (*10*). Although less intensive, generally lower-yielding production may generate local environmental benefits, it is critical to consider potential indirect consequences, in particular the risk that land is cleared for agricultural production elsewhere to compensate for locally lower yields (*5*).

(iii) Food security requires as much attention to increasing environmental sustainability as to raising productivity. SI does not mean business-as-usual food production moderated by marginal improvements in sustainability. As we envisage it, SI demands radical rethinking of food production to achieve major reductions in environmental impact. In some areas, increases in yield will be compatible with environmental improvements. In others, yield reductions or land reallocation will be needed to ensure sustainability and deliver benefits such as wildlife conservation, carbon storage, flood protection, and recreation. An overall increase in production does not mean yields should increase everywhere or at any cost: The challenge is context- and location-specific.

(iv) SI denotes a goal but does not specify a priori how it should be attained or which agricultural techniques to deploy. The merits of diverse approaches—conventional, "high-tech," agro-ecological, or organic—should be rigorously tested and assessed, taking biophysical and social contexts into account. Building the social and natural science evidence base to allow formulation of context-dependent SI strategies is a research priority.

### Other Policy Goals Interfacing with SI

Policy-makers need to consider multiple goals for the food system in multifunctional landscapes (*11*). Although there will often be synergies, tensions among competing priorities also arise. Here, we highlight five areas that interface with SI and explore ways in which shared agendas might best be pursued.

(i) Biodiversity and land use. By using and contaminating land and water, agriculture is a greater threat to biodiversity than any other human activity (*4*). One response is to integrate agriculture and conservation goals through wildlife-friendly "land-sharing" practices. However, because yields are typically lower, more land is needed for a given output. This suggests an alternative approach: land sparing, in which yields are increased on farmed land, freeing up land elsewhere for conservation (*12*). SI could involve either approach, but understanding which is more beneficial, and in what context, is hampered by the shortage of relevant





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quantitative data. The practical effectiveness of both approaches hinges on real-world constraints—coupling on-farm yield increases to safeguards for conservation elsewhere (in the case of land-sparing), and design and widespread adoption of low-impact farming approaches (for land-sharing). Successful SI will require (a) establishing how land-sharing can deliver sufficiently high yields and multiple ecosystem services, (b) quantifying trade-offs between yields and different environmental benefits and assessing how best to resolve them across different circumstances and spatial scales, and (c) exploring policy and market mechanisms that enhance implementation of sharing or sparing initiatives.

(ii) Animal welfare. The word "intensification" is particularly problematic for those concerned with animal welfare. It is often associated with forms of production that have demonstrably negative effects on animal health and welfare. Although attention to many aspects of welfare can increase productivity (particularly where low productivity is caused by disease, insufficient feed, and other causes of ill health), some strategies, such as highly selective breeding for extreme levels of production, can produce congenitally harmed animals and undermine well-being in other ways (*13*, *14*). For us, SI goals are contingent upon acceptable standards of welfare. In applying SI to the livestock sector, we need to (a) place SI within a wider ethical framework that may disbar some potential options, (b) identify areas with the greatest potential for joint SI and welfare gains, and (c) recognize that there are limits on our ability to meet projected future livestock product demand while also achieving animal welfare and environmental goals, limits that signal the need for urgent action to reduce overconsumption and escalating demands.

(iii) Human nutrition. Food security incorporates the need for micronutrient, as well as energy and protein, adequacy (*15*). Progress on the former has lagged behind efforts to end hunger. Good human nutrition requires a diverse diet. It is important that SI does not result in narrowed dietary options, especially for poor consumers. This might occur through excessive dependence on a few high-yielding commodity crops bred for productivity rather than for micronutrient quality. Post-harvest fortification as well as breeding strategies (including biofortification) that improve crops' nutritional content can help mitigate these problems but may be counterproductive if they exacerbate reduced dietary diversity. SI farming strategies thus need to take nutrition into account. This requires us to (a) assess impacts of current production approaches on the spectrum and adequacy of food available to local communities, (b) better understand the dietary importance for many poor people of wild foods and often-neglected indigenous crops and livestock and take this into account in land-use policy, and (c) apply traditional and modern breeding techniques to improve yields of neglected crop and livestock species.

**Increase in rice yields.** Rice yields increased greatly during the "Green Revolution" of the 1970s and 1980s. The challenge now is to make equivalent progress on sustainability.

(iv) Rural economies. In many countries, agricultural policy is inextricably linked with economic support for rural economies. The design and operation of agricultural support could be radically improved, and SI goals need to be developed within this broader policy context. We should (a) identify where current support mechanisms can be reoriented to incentivize SI, (b) revitalize and reinvent extension services to provide the support required for SI implementation, and (c) use modern information and communications technology and appropriate financial instruments to enable food producers applying SI practices to be more resilient to shocks and responsive to market signals.

(v) Sustainable development. In least-developed countries and for low-income producers, improving yields and farmer incomes are priorities but are frequently hampered by insufficient economic, physical, and human capital, themselves held back by institutional failure. Targeting investment in agriculture as an engine of economic growth is receiving new attention, as is the possibility that low-income countries can orient production along more sustainable pathways (*16*). SI needs to engage with the sustainable development agenda to (a) identify SI agricultural practices that strengthen rural communities, improve smallholder livelihoods and employment, and avoid negative social and cultural impacts, including loss of land tenure and forced migration; (b) invest in the social, financial, natural, and physical capital needed to facilitate SI's implementation; and (c) where sustainability objectives (e.g., GHG mitigation or biodiversity protection) require actions that may carry economic costs, develop mechanisms to pay poor farmers for undertaking such measures.

## Conclusion

SI is a new, evolving concept, its meaning and objectives subject to debate and contest. But SI is only part of what is needed to improve food system sustainability and is by no means synonymous with food security. Both sustainability and food security have multiple social and ethical (*17*), as well as environmental, dimensions. Achieving a sustainable, health-enhancing food system for all will require more than just changes in agricultural production, essential though these are. Equally radical agendas will need to be pursued to reduce resource-intensive consumption and waste and to improve governance, efficiency, and resilience.

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